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NOATAK RIVER SONAR PROGRESS REPORT

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and

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INTRODUCTION

Noatak River chum salmon (*Oncorhynchus keta*) and arctic char (*Salvelinus alpinus*) support commercial and subsistence harvests in Kotzebue Sound and the lower Noatak River. Effective management of the fisheries resource requires knowledge of wild stock escapement. Two indices of escapement are currently available: catch per unit effort (CPUE) data from a test-netting project near the river mouth and results from aerial surveys of clear-water spawning areas. Silty water and the extensive, multi-channel river mouth preclude visual counts of migrating fish.

This project was designed to assess the feasibility of using hydroacoustic (sonar) techniques to count migrating Noatak River chum salmon and char. If feasible, sonar estimates of daily fish passage would provide timely escapement information to fishery managers. In addition, annual escapement estimates would enable prediction of future year run strength and could eventually be used to establish escapement goals.

METHODS

Site Selection

The Noatak River flows approximately 680 km from its headwaters in the Schwatka Mountains to Kotzebue Sound. The lower 50 km of the river was surveyed for possible sonar sites on 6-7 August 1988. The river's lower 32 km are characterized by an extensive delta area with multiple channels and unstable banks (Figure 1). The lower Noatak River canyon (km 39) was chosen for sonar deployment because of the single, narrow channel, stable banks, proximity to the mouth, and favorable bottom profile. At km 39, the river is approximately 200 m wide and 20 m deep, and the river bottom has a relatively constant slope from both banks.

Camp Construction

Beginning on 5 July 1989, camp living quarters were constructed on a treeless bench approximately 5 m above the highest water mark on the right (north) bank of the river. Quarters consisted of two canvas wall tents for sleeping (four bunks each) and one for cooking. An additional wall tent was erected 150 m downstream and closer to the river to house the sonar equipment. A 3.5 kw gasoline generator, located midway between camp and the sonar tent, supplied 110 VAC power to both. Camp construction was completed by 18 July 1989; sonar equipment was installed and operational by 25 July 1989.

Dual-Beam Sonar Theory and Application

See Ehrenberg (1972) for a detailed explanation of the theory of dual-beam sonar. Recent work (Skvorc unpublished) has shown that a riverine dual-beam sonar system can successfully distinguish two species of salmon (*Oncorhynchus tshawytscha* and *O. nerka*) which differ substantially in size. Readings of target strength (a correlate of target size) on individual fish are highly variable, but with sufficient size differences between species, and adequate numbers of fish ensonified, the relative proportions of species passing through the sonar beam can be estimated.

Sonar Data Acquisition

Sonar equipment deployed on the Noatak included a Biosonics model 102 echo sounder; Biosonics 6°x15° circular dual-beam transducer; Biosonics model 111 thermal chart recorder; Biosonics Echo Signal Processor (ESP), with associated software, installed in a Compaq 386/20 personal computer; and a Hewlett Packard model 54501A digital oscilloscope. The transducer was mounted on a metal tripod placed 3-15 m offshore; aiming was accomplished using a remote-controlled dual-axis rotator manufactured by Remote Ocean Systems (R.O.S.).

Sound pulses were generated by the sounder at 420 kHz with a pulse width of 0.4 ms. Pulse repetition rate varied from 6.7 to 9.1 sec^{-1}, and effective range was 80 m.

The ESP enabled customized filtering of returning echoes, automated data storage, and real-time monitoring of data acquisition. We set minimum voltage thresholds and pulse width criteria, which ESP used to eliminate echoes not likely to have originated from fish. Minimum voltage thresholds were range-dependent and tailored to current noise patterns, which varied due to changing river bottom profile and transducer aim. For each echo which met the acquisition criteria, the ESP wrote information on voltage, pulse width, and range to the personal computer hard disk. A new data file was automatically created every 30 minutes. The ESP also displayed updated summaries of target strength and range distribution. This feature, together with oscilloscope and chart recorder output, enabled us to continuously monitor system performance.

Under ideal conditions, the sonar equipment ran continuously, 24 hours per day, seven days per week, excluding half-hour periods at noon and midnight. During these periods the generator was refueled and maintained, and data were copied to floppy disks. Data acquisition was interrupted when changing river conditions necessitated moving the tripod and/or re-aiming the transducer.

Sonar data acquisition was monitored from 8 AM to 12 midnight, six days per week. Each day was divided into three six-hour shifts (0800-1400, 1300-1900, 1800-2400), each monitored by a fisheries technician. During shift overlaps (1300-1400 and 1800-1900), one of the technicians assisted with test-netting. The technician monitoring the sonar tallied fish counts and recorded water level and weather conditions every half-hour, maintained a detailed log of sonar operations, and periodically recorded the time on the chart recording. Fish counts were tallied by 10 m range (distance from transducer) intervals. Technicians followed a standard operating procedure and notified the crew leader or project leader in the event of non-standard incidents.

With only one transducer deployed, the ESP sufficiently automated data acquisition and storage so that the sonar system could run unmonitored for several hours at a time. We therefore operated the sonar unattended at night

(0000-0800). Quality of data was occasionally compromised when transducer aim or river conditions changed unnoticed, so on Sunday, system operation was checked periodically throughout the day. Sonar data were acquired from 25 July to 29 August 1989.

A dual-beam data processing (DBDP) computer program was used for on-site processing of acoustic data. Briefly, DBDP aggregated echoes into groups likely to have come from the same fish, by clustering echoes in time and space. DBDP also calculated mean target strength for each fish and printed a frequency table of target strength by range.

Test-netting

We deployed five nets a total of 62 times from 23 July to 30 August:

1) 31 m beach seine
2) 62 m experimental gill net
3) 102 mm mesh gill net (46 m by 6.2 m)
4) 140 mm mesh gill net (46 m by 6.2 m)
5) 149 mm mesh gill net (93 m by 4.6 m)

The experimental gill net had four 16 m panels, with 25 mm, 51 mm, 76 mm, and 102 mm mesh; and was deployed in the manner of a beach seine, with the small mesh panel inshore. The other gill nets were drifted for 13 to 93 minutes and checked from a small skiff (5.1 m Boston Whaler or 5.5 m Lund). All nets were deployed from a sand beach 10 m to 200 m downriver from the sonar tripod. Gill nets were drifted diagonally across the river; drifts were usually terminated when the offshore end neared the far shore. Most test-netting was done during early afternoon (1300-1500) or early evening (1800-2000).

RESULTS AND DISCUSSION

Comparison of Sonar Counts with Other Indices of Abundance

Large numbers of targets were present within 30 m of shore when the sonar equipment was first installed on 24 July. Seining from the beach with an experimental gill net showed these to be primarily broad whitefish (*Coregonus nasus*). Whitefish numbers began diminishing approximately 1 August. Starting in late August, beach seining showed increasing numbers of least cisco (*C. sardinella*), with occasional small (ca 250 mm) arctic char. No salmon (*Oncorhynchus* spp.) were caught while beach seining (Table 1).

Most targets beyond 30 m range were apparently chum salmon. Gill nets (140 mm, and 149 mm mesh), drifted diagonally across the river 44 times from 23 July to 29 August, yielded >95% chum salmon (Table 1).

Based on this preliminary knowledge of horizontal fish distribution, we chose daily counts of sonar targets between 30 m and 80 m range to compare with other indices of chum salmon abundance. These indices were: CPUE for 140 mm and 149 mm gill nets at the sonar site, CPUE from an ADF&G test-net project on the lower Noatak River (km 15), and CPUE of the commercial fishery in Kotzebue Sound (Figure 2). Sonar counts were rank-correlated with sonar-site CPUE ($r_s = 0.48$, $n = 29$, $P<0.01$), but not with lower Noatak River CPUE or Kotzebue Sound CPUE ($r_s = -0.01$, $n = 25$; and $r_s = -0.04$, $n = 11$; respectively; $P>0.1$). Sonar-site CPUE was rank-correlated with lower Noatak CPUE ($r_s = 0.42$, $n = 22$, $P = 0.03$), but not with Kotzebue Sound CPUE ($r_s = 0.51$, $n = 8$, $P>0.05$). (However note smaller sample size.)

We tried lagging lower Noatak River CPUE from one to five days, to account for migration time from river km 15 to km 39; but this failed to significantly improve its rank-correlation with sonar counts ($r_s = -0.37$ to 0.10, $n = 22$ to 26, $P>0.1$), or with sonar-site CPUE ($r_s = -0.19$ to 0.34, $n = 20$ to 25, $P>0.05$).
The lack of correlation between Kotzebue Sound CPUE and Noatak River salmon escapement indices is partially the result of the confounding effect of Kobuk River chum salmon in the commercial fishery. Though there is considerable

overlap, the chum salmon run peaks earlier on the Kobuk River than on the Noatak. The relatively weak correlation between fish passage indices at the sonar site and CPUE at the lower Noatak river test-fish site suggests that the time required by salmon to navigate the lower river is variable, and lack of a consistent lag between the two locations suggests that the average migration time is short.

Problems Encountered

As expected from experience at other sonar installations, an optimal transducer aim proved somewhat elusive. Repeated movement of the tripod was necessary before we found a location where the river bottom was not convex for the first 20 m from shore. Initially, atypical noise patterns made detection of fish difficult from 18 m to 23 m. The noise appeared to originate from neither the river bottom nor the water surface, but was possibly related to unusual water current phenomena. The noise began diminishing on 7 August coincident with rising water levels and a series of transducer moves.

Rain often caused increased surface noise, which hampered data collection. The beam of the 6° transducer ensonified much of the water column; for instance an artificial target at 33 m range was detectable from river bottom to water surface. As a result, bottom and surface noise were often present simultaneously. This limited our ability to make downward adjustments in transducer aim to minimize surface noise during rainy weather. We plan to use a transducer with a narrower, elliptical beam in 1990.

Sonar counts declined to almost zero during 12-16 August, which coincided with a period of rapidly rising, turbid water and high debris load (Figure 2). We had difficulty detecting an artificial target beyond 30-40 m range during this period, indicating possible attenuation of the sonar signal. However test-net CPUE at the sonar site was also low during this period (Figure 2). Sonar counts and sonar-site CPUE rebounded when water level began falling on 17 August.

Whitefish and chum salmon did not overlap in mid-eye-to-fork length (Figure 3), which increases the likelihood that they can be differentiated based on target strength alone. However, preliminary analysis of target strength data indicates that, during the whitefish run, median target strength was slightly greater inshore (0-20 m) than offshore (20-80 m). This is contrary to netting results (discussed above) which showed whitefish (small targets) inshore and salmon (large targets) offshore. Also, for unknown reasons, readings of target strength on a standard artificial target were more variable than expected.

Several equipment-related problems were also experienced. The R.O.S. rotators, newly designed with a clutch-like detent to protect fragile gears, failed to rigidly attach the transducer to the tripod. Consequently, transducer aim frequently shifted when exposed to large boat wakes, or for no apparent reason. This necessitated frequent re-aiming. R.O.S. is currently designing a more rigid detent mechanism.

At a pulse repetition rate of 9.1 sec^{-1}, the ESP only acquired echoes from alternate pulses, skipping every other pulse. Slowing the pulse rate to 6.7^{-1} remedied the problem, but more experimentation is required to isolate the problem to the ESP or the sounder and to precisely determine limitations on ping rate for this application.

Noatak Sonar Outlook

Resolution of the above technical problems will require considerable data analysis and experimentation in 1990. Nevertheless, prospects for successful sonar enumeration of Noatak River chum salmon appear good. One season of experience confirmed initial impressions that the site is basically favorable for sonar deployment. Furthermore, separation of species at this site may prove less difficult than originally perceived. Chum salmon may be largely separable from whitefish based on distance from shore alone, though more netting is needed to verify this.

Lengths of arctic char caught at the sonar site (n = 22) had no definable mode and overlapped with chum salmon lengths (Figure 3), which would make differentiating char from chum salmon based on target strength difficult. However, large char appear to be too few in number to add appreciable bias to sonar estimates of chum salmon escapement. Relative abundance of char was apparently high in 1989; the proportion of char in the commercial catch (salmon + char) was larger than average (Fred DeCicco, Alaska Department of Fish and Game, Fairbanks, personal communication). Yet char comprised less than 2% of the catch in 149 mm mesh nets at the lower Noatak test-fishing site (Knuepfer, unpublished), and in 140 mm and 149 mm mesh gear at the sonar site (29 of 1921 and 7 of 386, respectively).

Priorities for the 1990 field season will include further investigation of the effect of water and weather conditions on sonar system performance, and collection of additional data to determine the feasibility of using target strength to distinguish chum salmon from whitefish.

LITERATURE CITED

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Ehrenberg, J.E. 1972. A method for extracting the fish target strength distribution from acoustic echoes. Pages 61-64 *in* Proc. 1972 IEEE Conf. Eng. Ocean Environ., Vol. 1.

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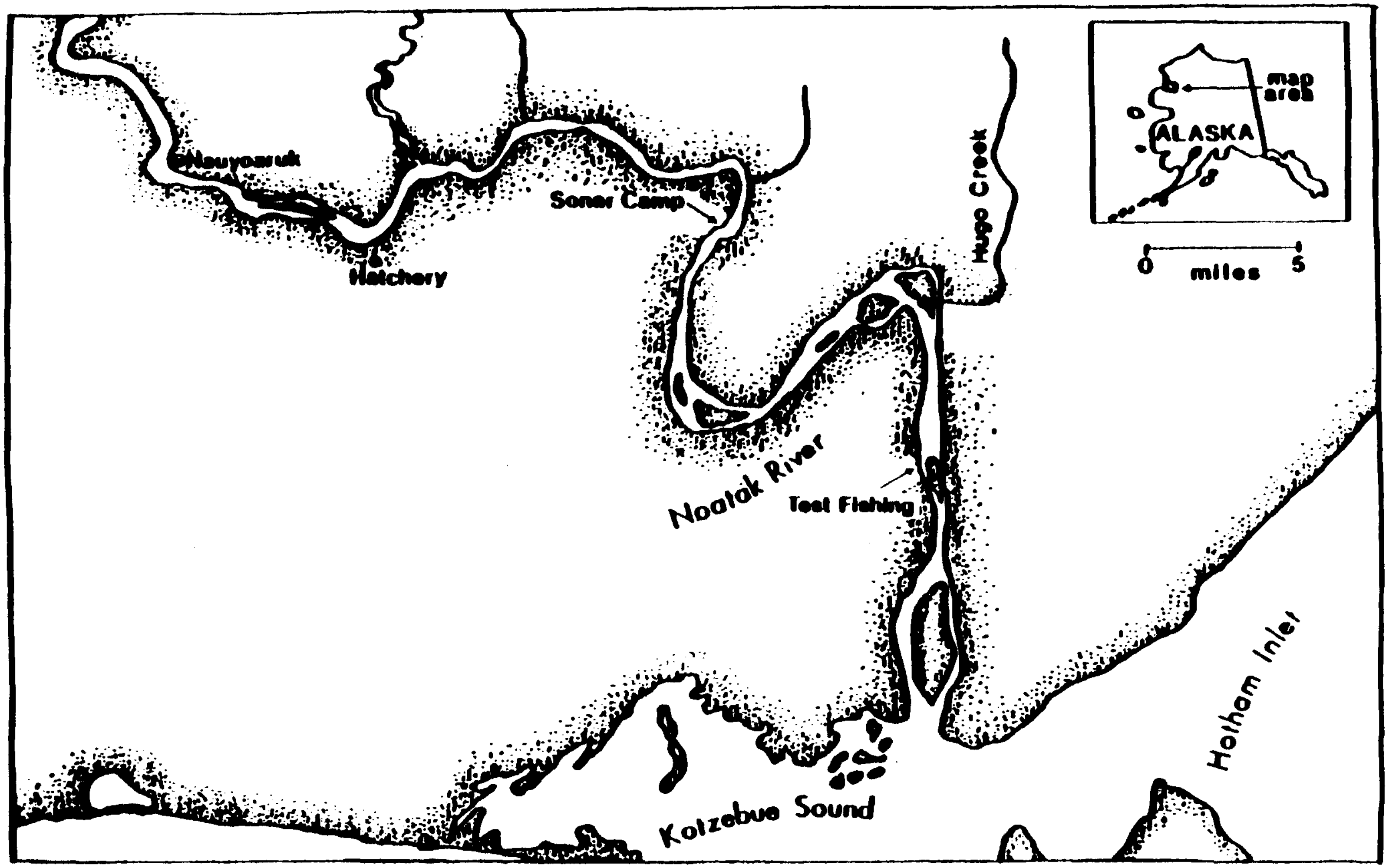

Figure 1. Location of Noatak River sonar camp and lower Noatak River test fishing site, 1989 (modified from Berning et al., 1987).

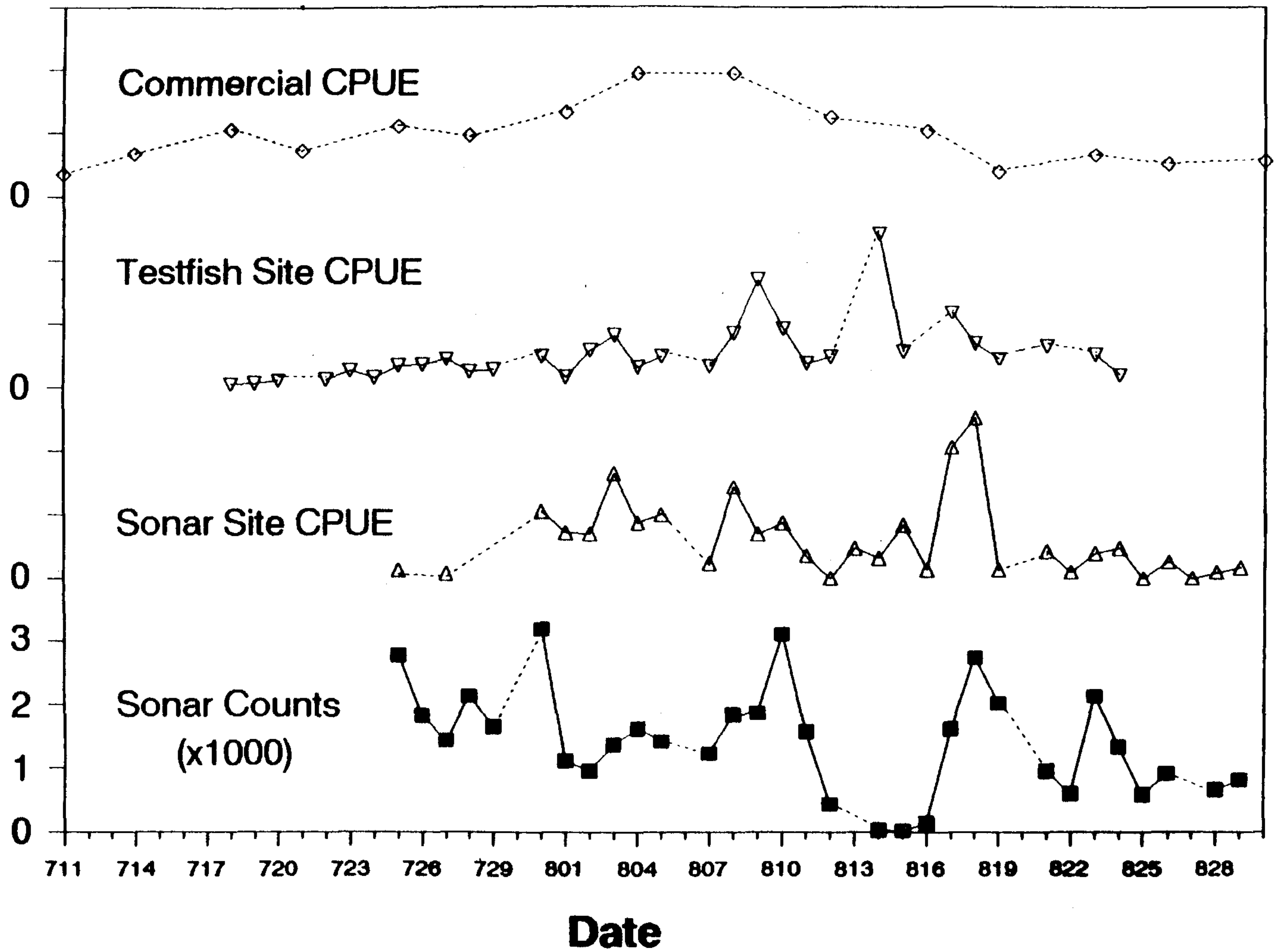

Figure 2. Sonar counts of fish at 30-80 m from the transducer, 25 July to 29 August, 1989; compared to other indices of chum salmon run strength: CPUE from the commercial fishery in Kotzebue Sound, CPUE at the testfish site (Figure 1) on the lower Noatak River, and CPUE at the sonar site.

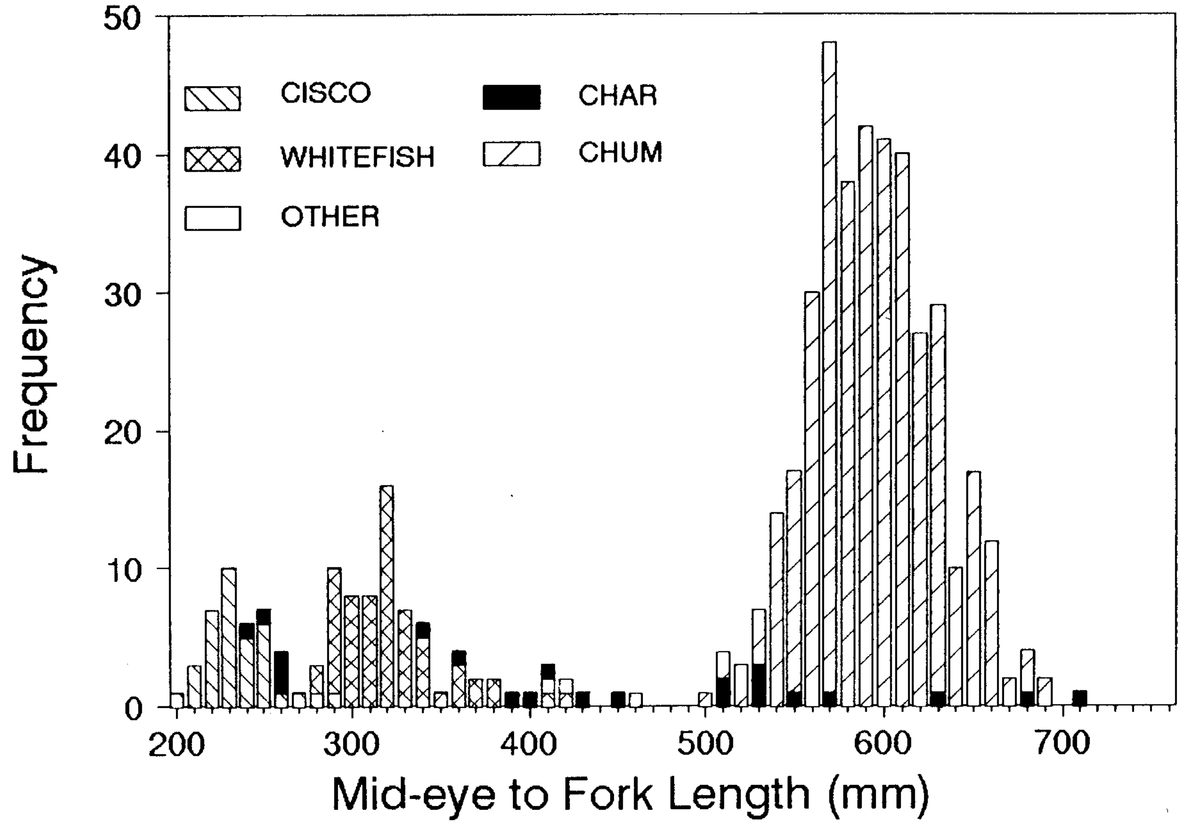

Figure 3. Frequency distribution of lengths (measured mid-eye to fork) of six species of fish caught during test-netting at the Noatak River sonar site during July and August, 1989. CISCO = least cisco (*Coregonus sardinella*), WHITEFISH = broad whitefish (*Coregonus nasus*), OTHER = long-nosed sucker (*Catastomus catastomus*) and pink salmon (*Oncorhynchus gorbuscha*), CHAR = arctic char (*Salvelinus alpinus*), CHUM = chum salmon (*Oncorhynchus keta*).

Table 1. Results of test-netting at the Noatak River sonar site from 23 July to 29 August 1989.

DATE	Beach Seines 0-30 m NET[a]	NUMBER OF FISH Whitefish	Other[b]	Gill Net Drifts 0-200 m MESH (mm)	TIME (min)	NUMBER OF FISH Chum	Other[b]
7/23				149	33	2	
7/25	EGN	14		149	12	1	
7/26	EGN	14		102		0	1 WF
7/27	EGN	9	1 CISCO, 1 SUCKER	149	61	3	
7/31	EGN	8		149	36	25	
8/01				149	49	35	
				102	23	0	1 CHAR
				149	40	9	
8/02				149	21	6	
				149	40	22	
8/03	EGN	0		149	30	33	
8/04				149	25	10	
				149	27	20	
8/05				149	24	16	
8/06				102	27	0	2 WF, 1 PINK
8/07	SEINE	2		140	20	3	
8/08				149	23	22	
8/09				140	13	6	
8/10				149	14	4	
				140	42	29	
8/11	SEINE	1		140	17	4	
	SEINE	0					
8/12				140	31	0	
8/13				140	20	6	
8/14				149	19	4	
8/15				102	22	1	
8/16				140	25	14	1 CHAR
				140	22	2	
8/17				149	27	37	
				102	30	0	4 CHAR
8/18				102	35	3	
				140	16	27	
8/19	SEINE	0	1 CISCO	149	24	2	1 CHAR
8/21				140	21	6	1 CHAR
				102	28	0	1 WF
8/22				149	30	2	2 CHAR
8/23				140	27	7	2 CHAR
				102	23	1	1 CHAR, 1 WF
8/24	EGN	2	1 CHAR	149	22	7	
	EGN	2	1 CISCO				
8/25				140	18	0	
				102	56	0	1 CHAR, 1 PINK
8/26	EGN	1	4 CHAR, 9 CISCO	149	35	6	
8/28				140	30	0	
8/29	EGN	2	1 CHAR, 6 CISCO	149	62	4	
	EGN	2	6 CISCO	102	37	0	

a) EGN = experimental gill net, SEINE = beach seine
b) WF = broad whitefish (*Coregonus nasus*)
CISCO = least cisco (*Coregonus sardinella*)
SUCKER = long-nosed sucker (*Catastomus catastomus*)
CHAR = arctic char (*Salvelinus alpinus*)
PINK = pink salmon (*Oncorhynchus gorbuscha*)